Preliminary Studies on π^0 Production in the MiniBooNE Antineutrino Data

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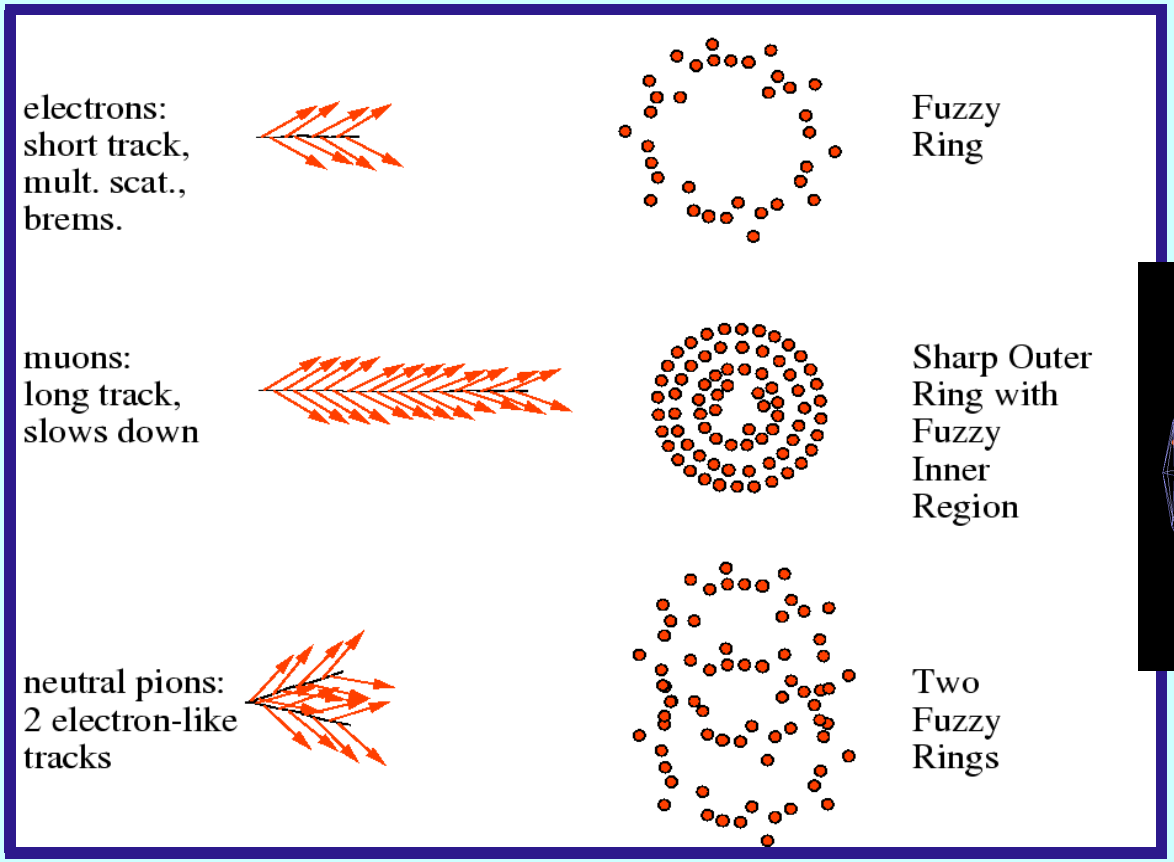
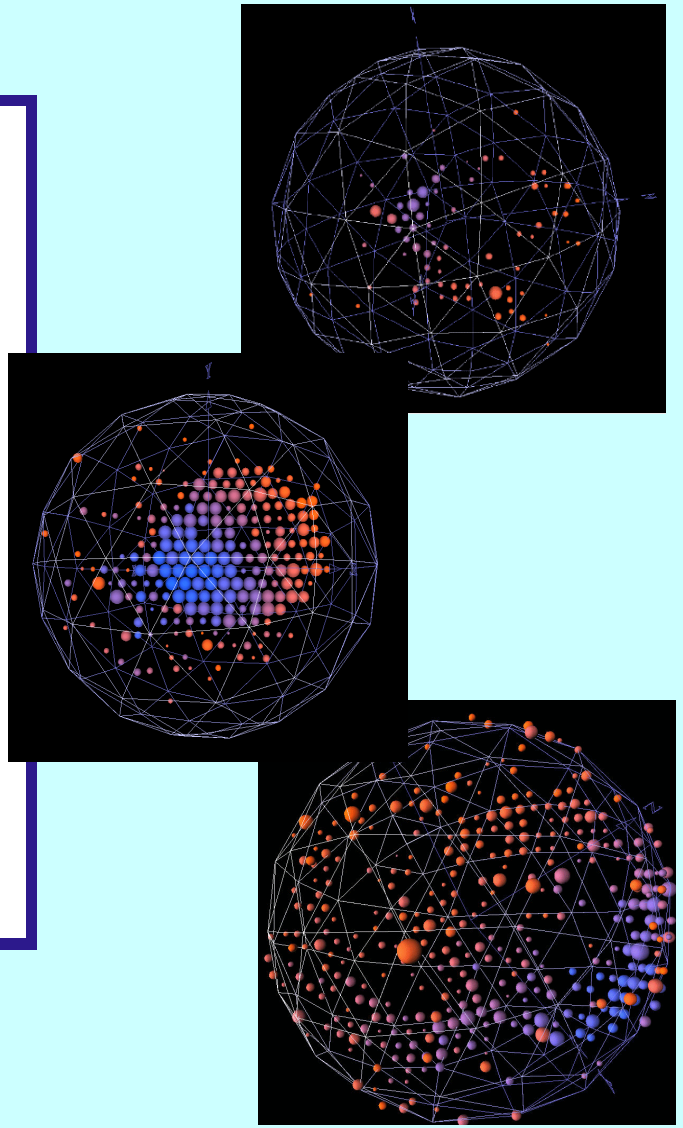
Happy Valentine's Day!

Generic Event Signature





Motivation for Studying NC π^0 Production

- To date, there is only one published measurement of the absolute rate of antineutrino NC π^0 production, the single largest background to future $\overline{\nu}_\mu \rightarrow \overline{\nu}_e$ oscillation searches; this measurement was reported with 25% uncertainty at 2 GeV.

- Current theoretical models on coherent π^0 cross sections can vary by up to an order of magnitude in their predictions at low energy, the region most relevant for ν oscillation experiments.

Oscillation Search Backgrounds: NC π^0 Production

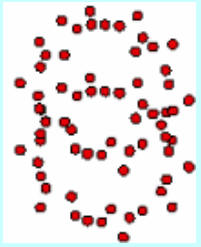
NC π^0's can be created through resonant and coherent production:

- Resonant NC π^0 production: $\bar{\nu}\,\mathrm{N} \rightarrow \bar{\nu}\,\Delta \downarrow \pi^0\,\mathrm{N}$
- Coherent NC π^0 production: $\bar{\nu}\,\mathrm{A} \rightarrow \bar{\nu}\,\mathrm{A}\,\pi^0$

Oscillation Search Backgrounds Cont'd

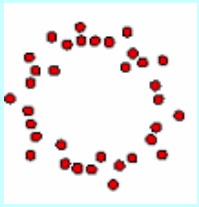
A π^0 decays promptly into two photons. π^0

$$\pi^0 \rightarrow \gamma\gamma$$



This event can be misidentified if there are not two resolvable tracks.

misID

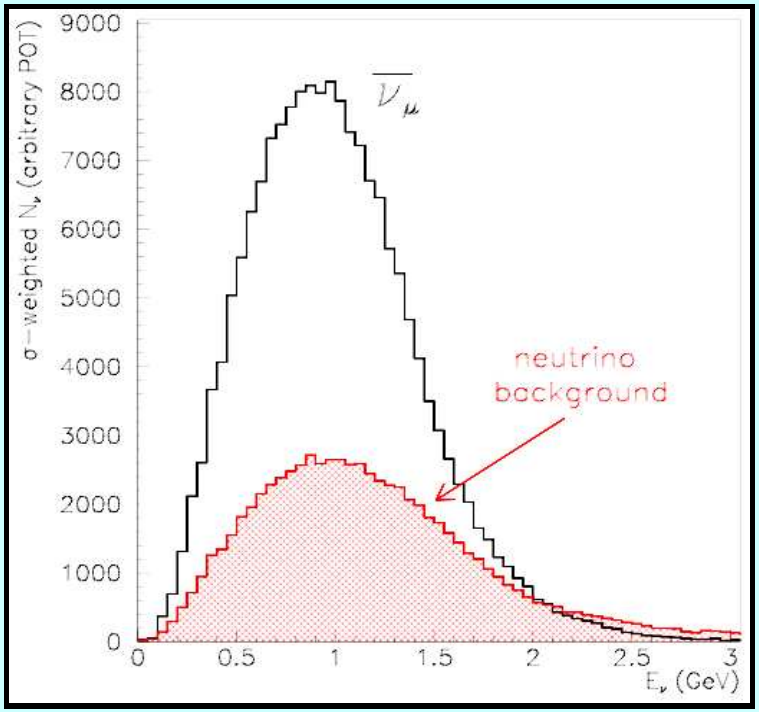


ν_e

Understanding of these events is crucial!

MiniBooNE Antineutrino Running

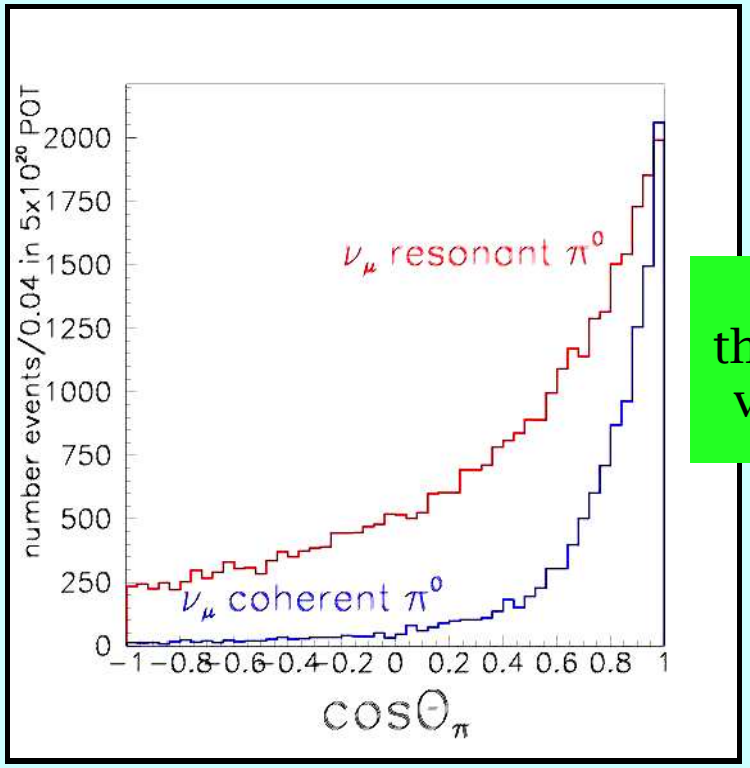
- Started antineutrino running in January 2006
- Has the world's largest sample of π^0's produced by antineutrinos (~900 events)!
- Need to contend with neutrino aka "wrong-sign" (WS) background



- In **antineutrino mode**, neutrinos are ~30% of the total events (as opposed to neutrino mode where antineutrinos are ~2% of the total events)

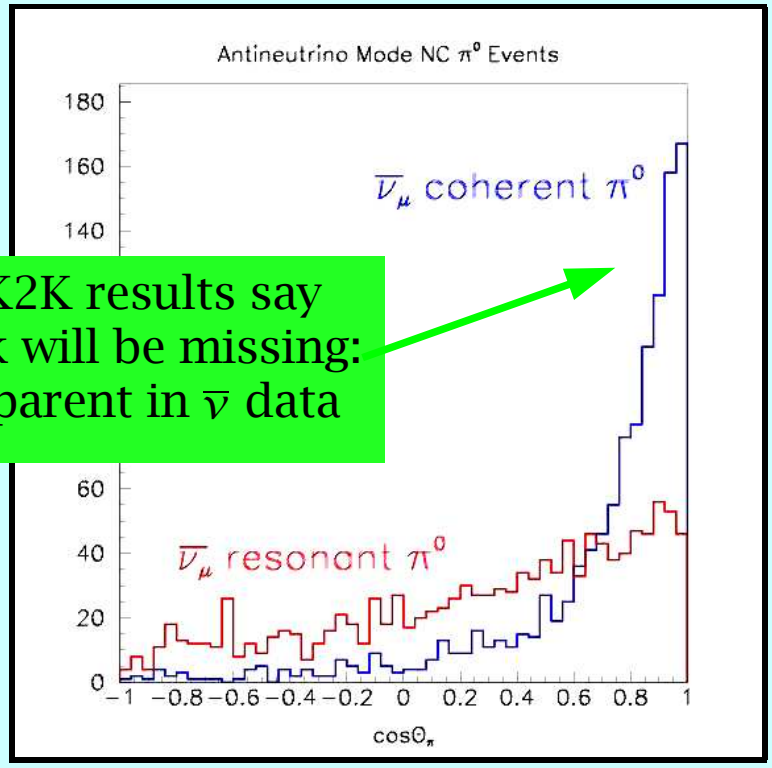
Coherent NC π^0's in ν vs. $\bar{\nu}$ Running

ν_μ NC π^0



- 20% is coherent production

$\bar{\nu}_\mu$ NC π^0



latest K2K results say this peak will be missing: very apparent in $\bar{\nu}$ data

- 40% is coherent production
- "enhanced" coherent sample

Generated π^0 angular distribution for NC ν (left) and $\bar{\nu}$ (right) scattering. Here θ_π is the angle of the outgoing π^0 in the lab wrt to the ν ($\bar{\nu}$) direction.

π^0 Event Selection

Analysis Pre-Cuts

- Only 1 subevent in the event found by the SplitEvent algorithm
- $N_{VETO}<6$, where N_{VETO} is the no. of veto hits associated with the subevent
- $N_{TANK}>200$, where N_{TANK} is the no. of tank hits associated with the subevent

Analysis Cuts (using the P-fitter reconstruction package)

- $R_e<500$ cm ...cut on the electron-like radius
- $-\log(L_e/L_\mu)>0.05$ ...likelihood cut favoring the electron
- $-\log(L_e/L_\pi)<0$ ...likelihood cut favoring the pion
- $50<M_\pi<500$ MeV...conservative mass cut
- $0<E_{\pi^0}(1.-\cos\theta_{\pi^0})<700$ MeV
- nuance=13,15 ...resonant π^0 production from antineutrinos
- nuance=96 ...coherent π^0 production
- nuance ≠13,15,or 96 ...background
- nuance=6,8 ...resonant π^0 production from neutrinos (WS)

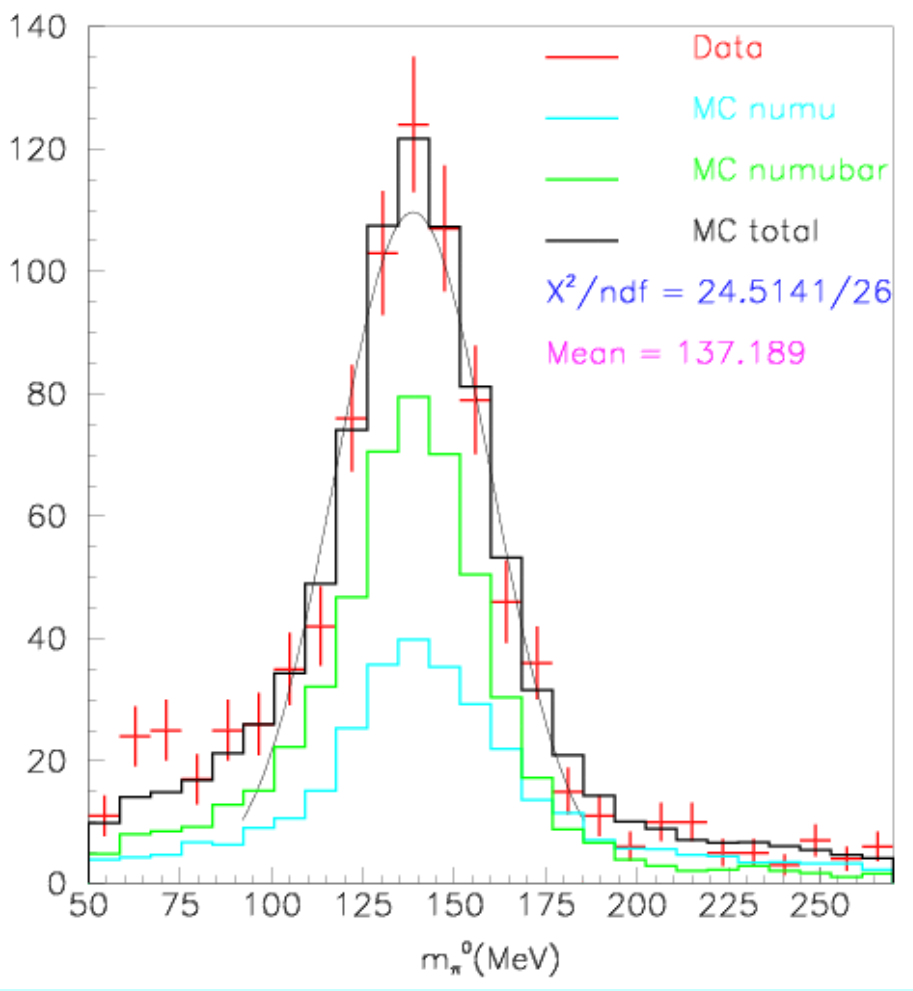
Preliminary Studies

We will see the following:

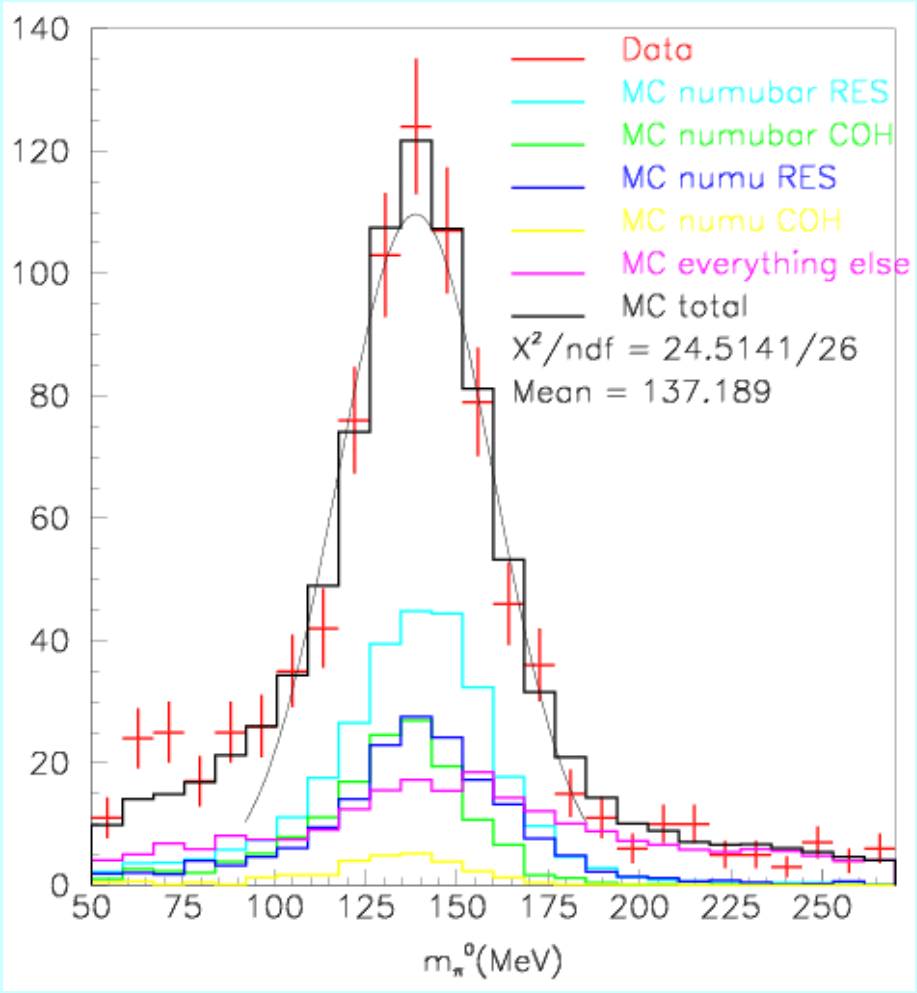
- There are indeed π^0's produced in our antineutrino data
- There is good agreement between data and MC
- Kinematic distributions are what we expect
- There is clear evidence for antineutrino NC coherent π^0 production

Note:
The data is from Jan.–Dec. 2006 and the MC is from the May 06 Baseline (no dirt)

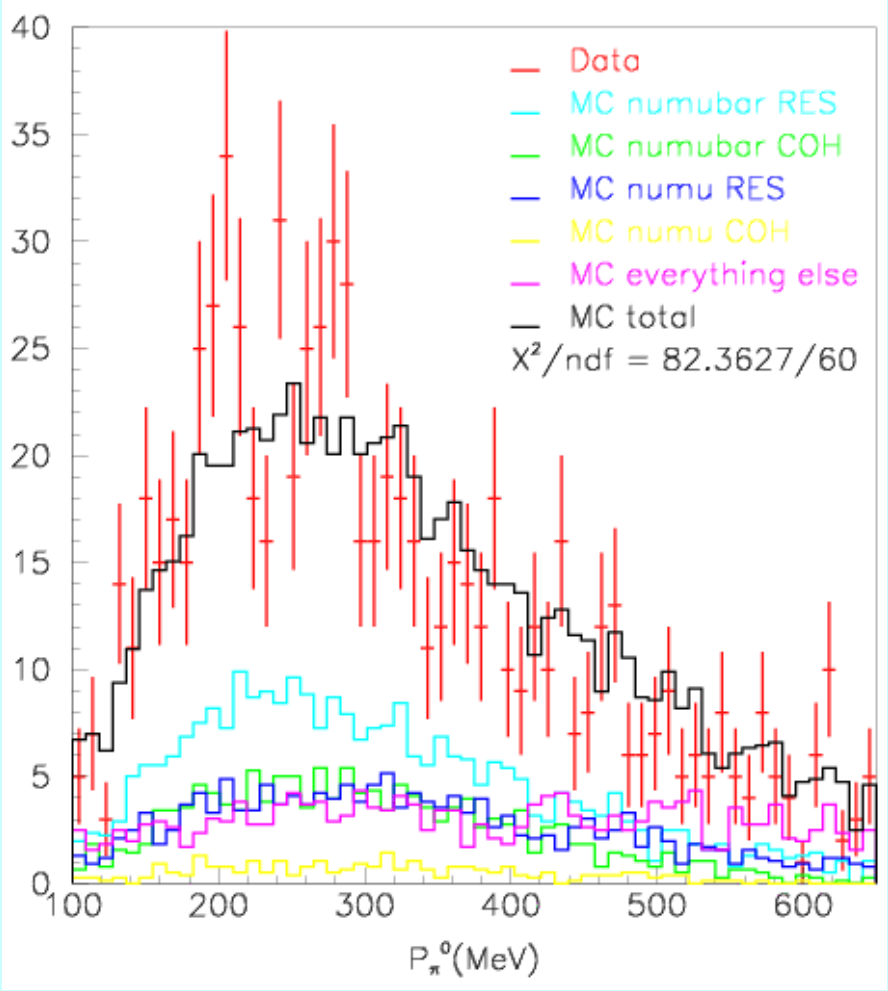
π^0 Mass Peak



π^0 Mass Peak

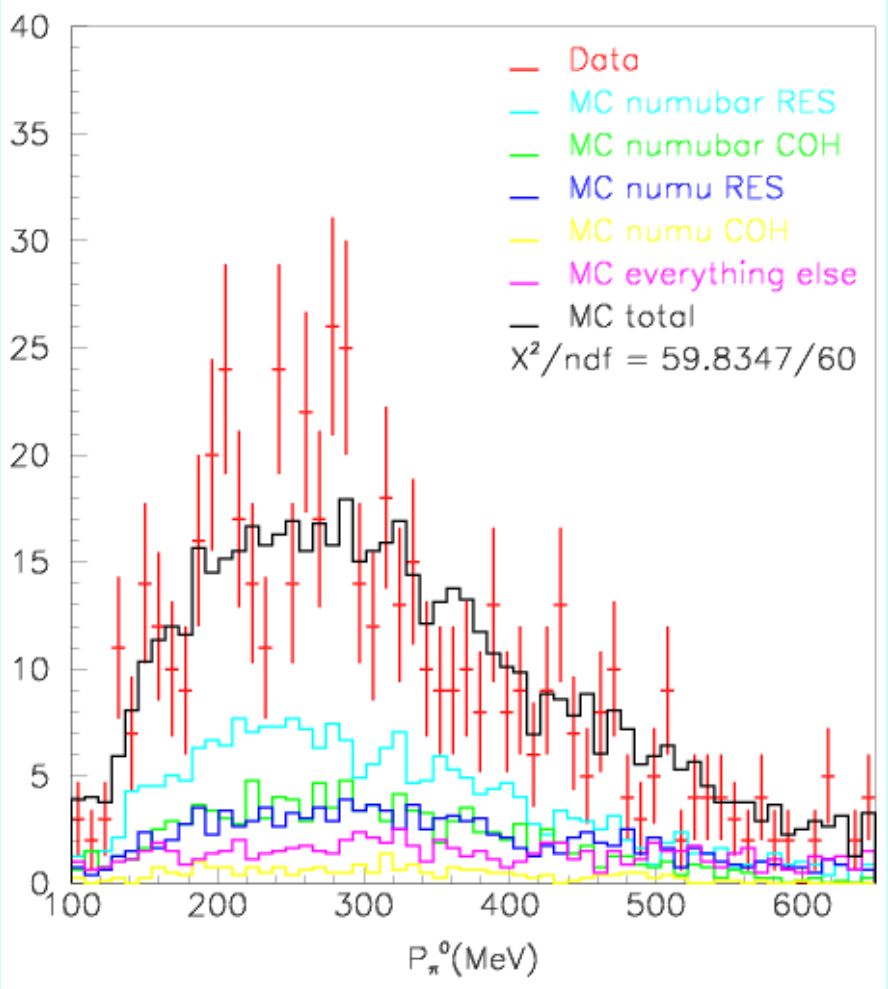


π^0 Momentum



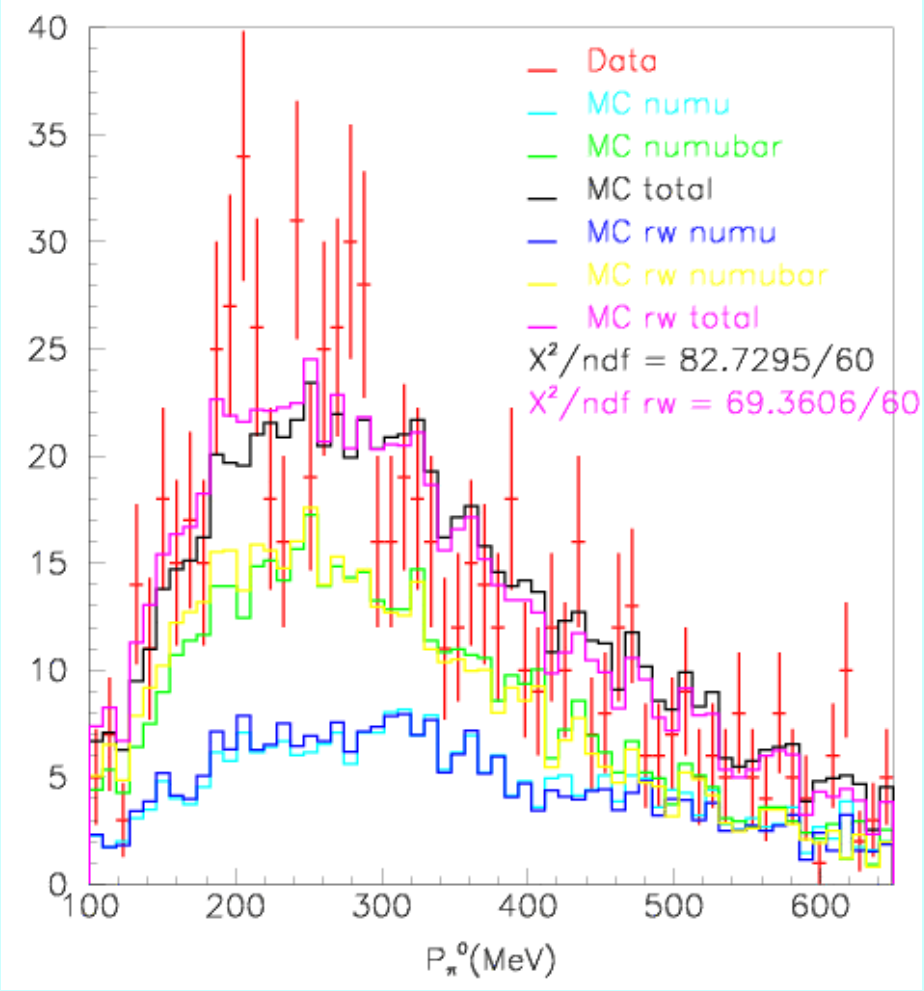
(50 MeV<m_{π^0}<500 MeV)

π^0 Momentum



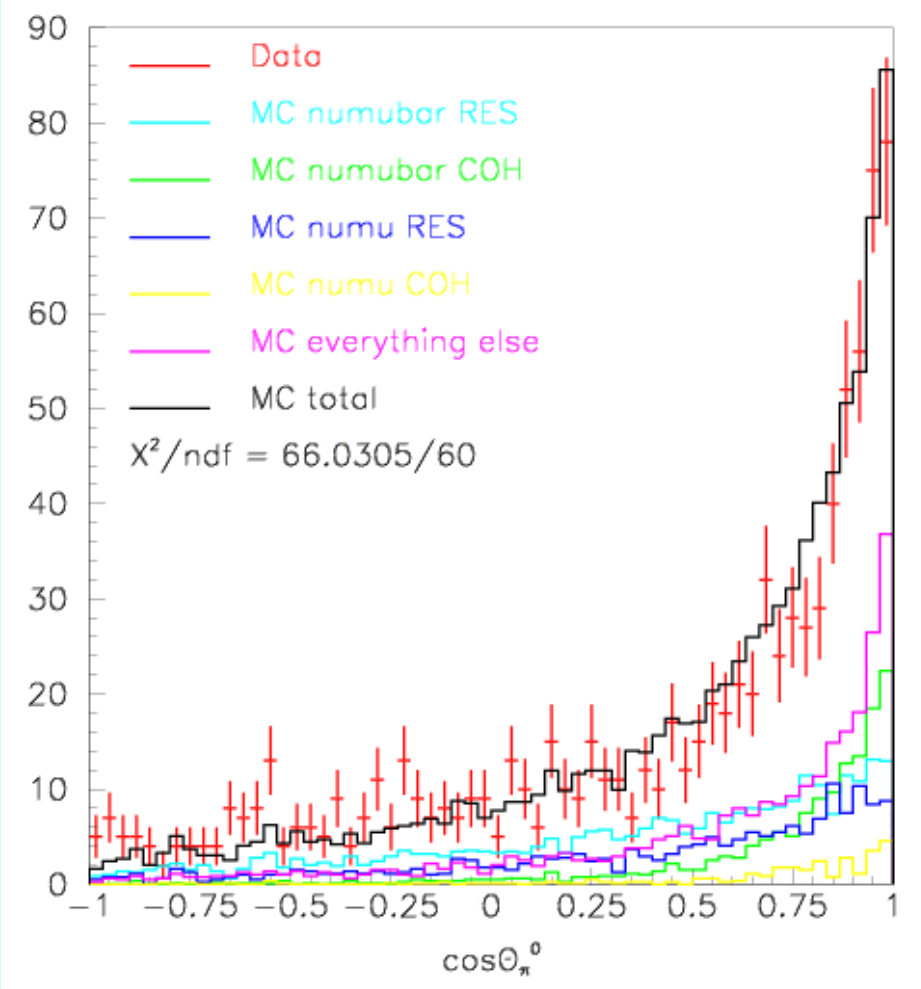
(100 MeV<m_{π^0}<170 MeV)

π^0 Momentum



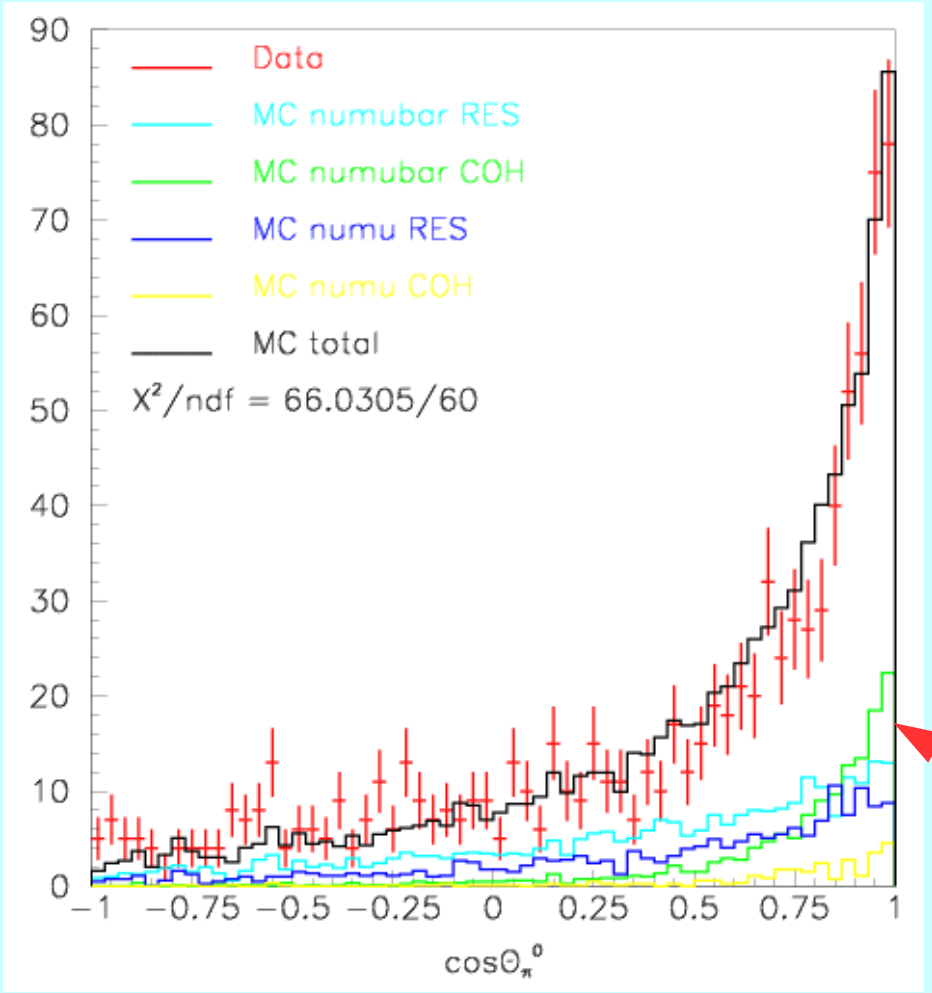
(50 MeV<m_{π^0}<500 MeV;
reweighted MC)

$\cos\theta_{\pi^0}$



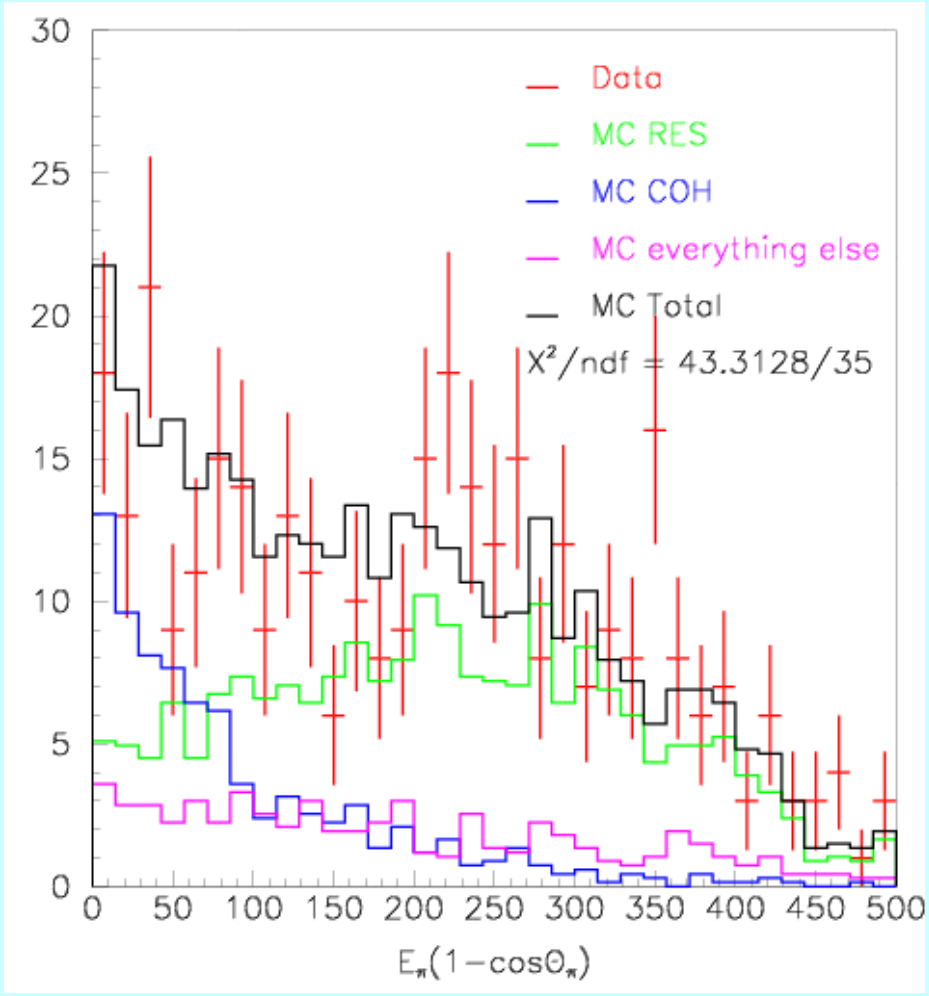
(θ_{π^0} is the angle of the outgoing π^0 in the lab wrt to the $\overline{\nu}$ direction)

$\cos\theta_{\pi^0}$

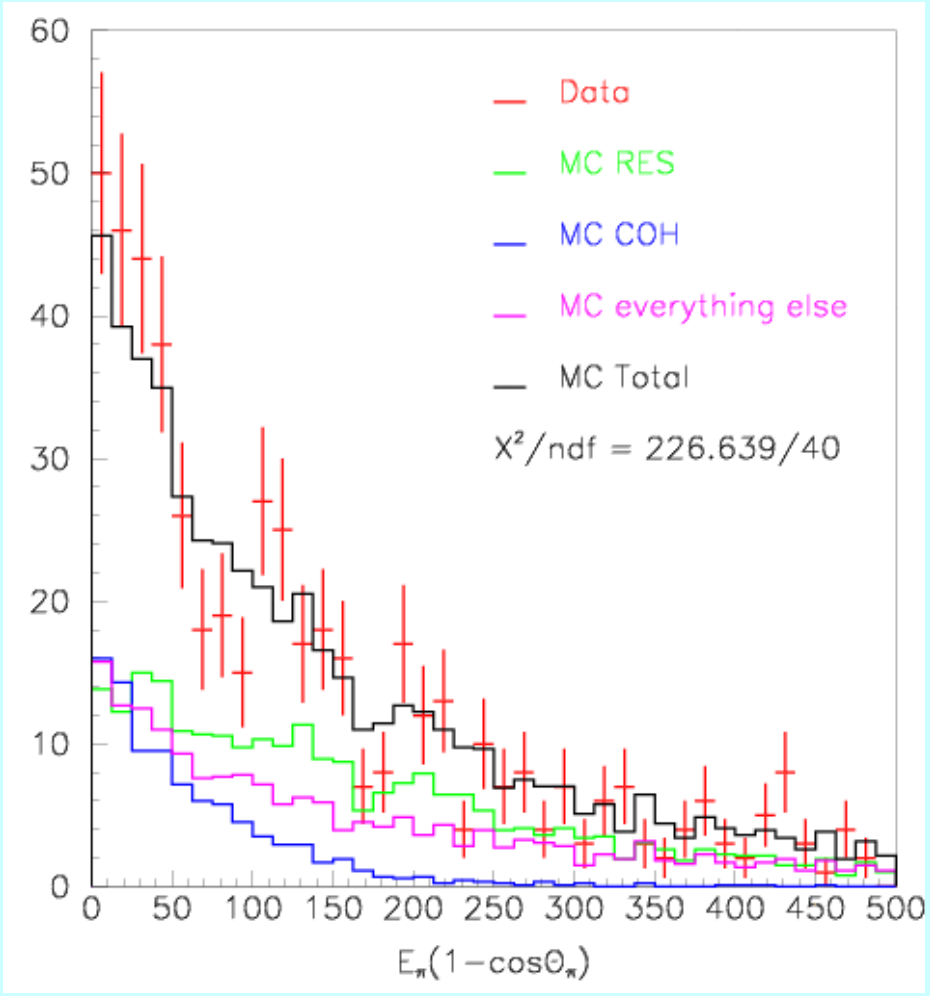


"missing peak"

Shape Comparison

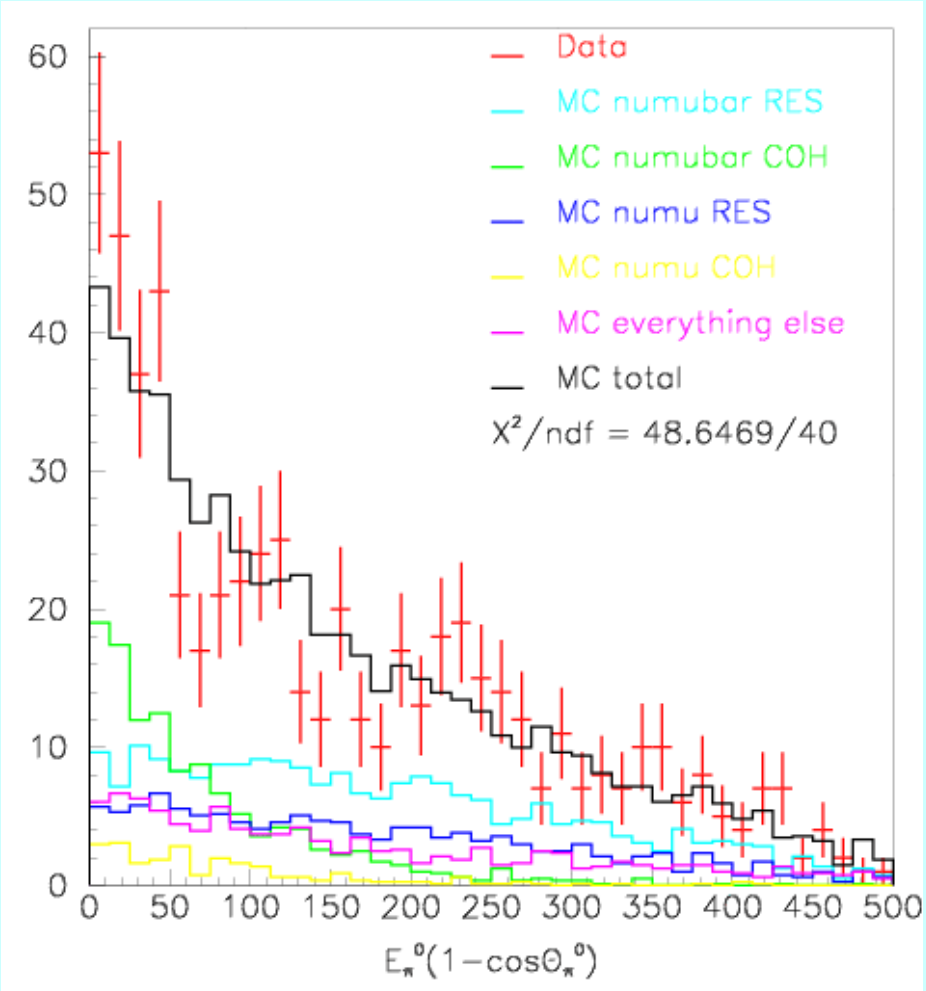


E_π<300 MeV

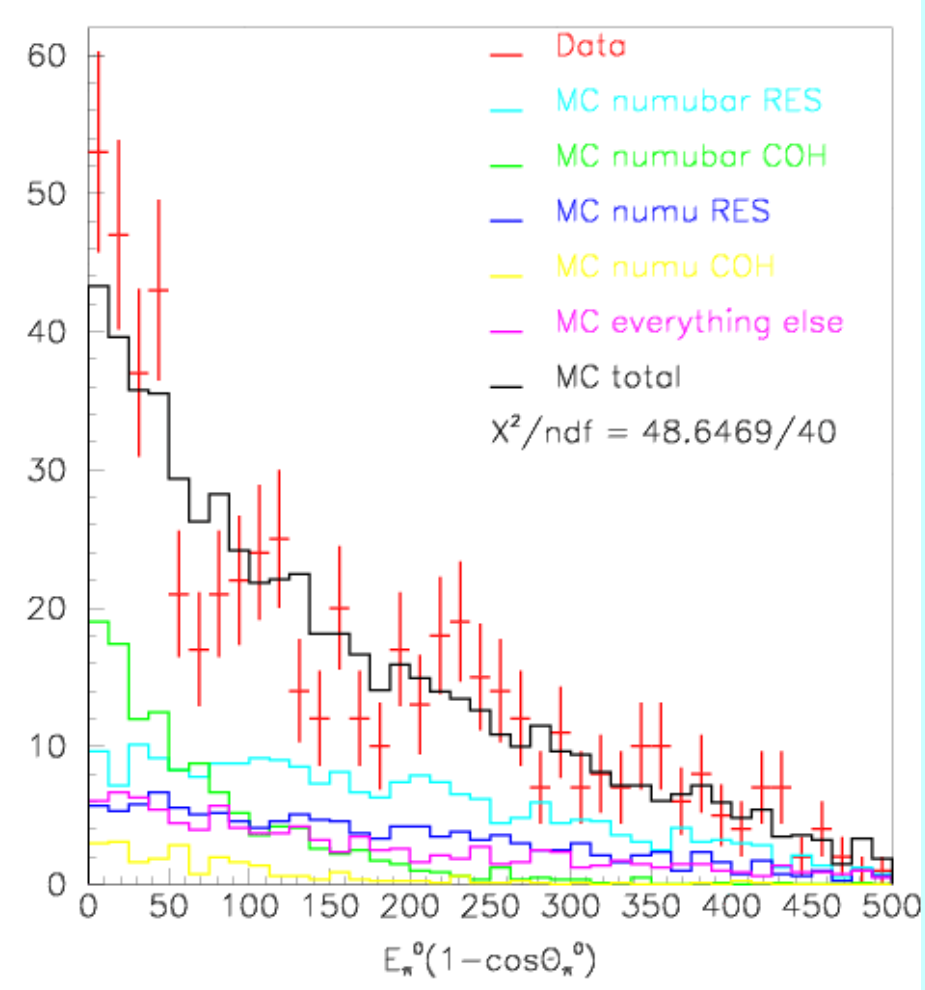


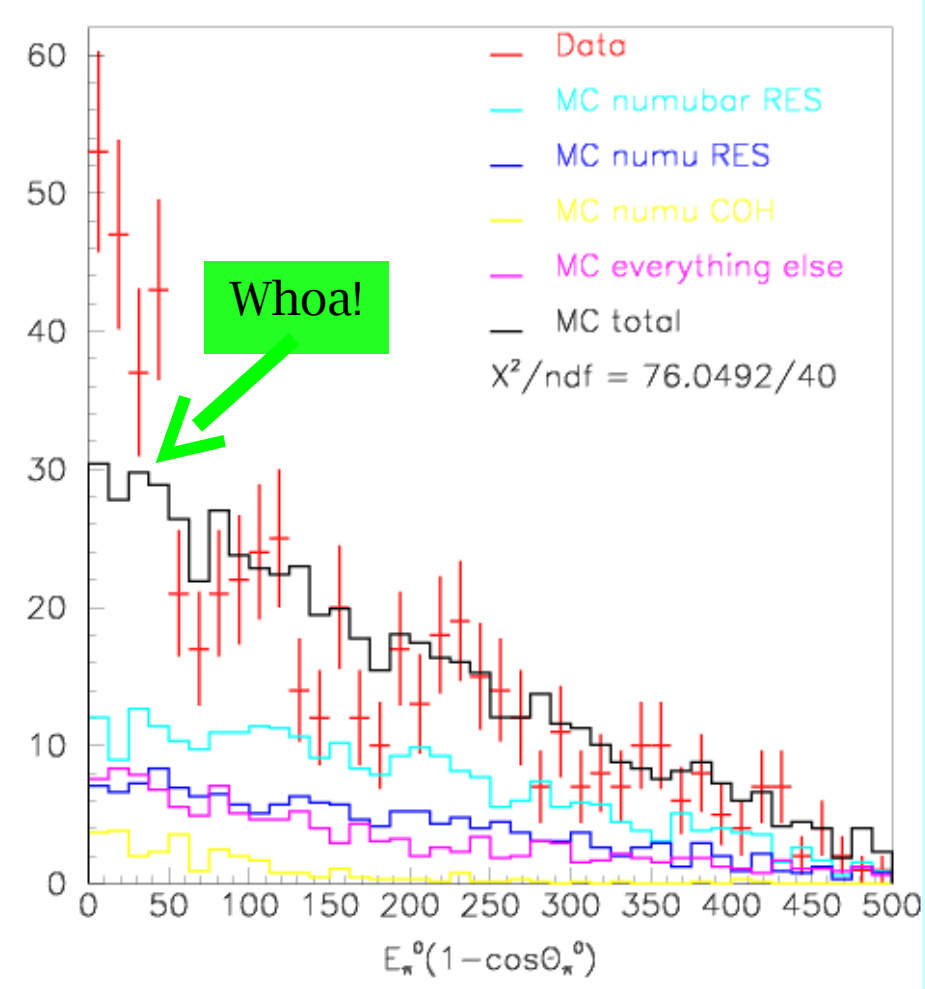
E_π>300 MeV

$E_{\pi^0}(1-\cos_{\pi^0})$



$E_{\pi^0}(1-\cos_{\pi^0})$





No numubar COH contribution

Summary

We saw the following:

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Up next:

- Construct template fits to the $E_\pi(1-\cos\theta_\pi)$ data in which the coherent and resonant contributions vary separately. This will be a 2–D fit that includes fitting the mass and WS background.
- Use updated MC (with fallen absorber plates) when they are available (coming soon!)
- Include systematic errors